DESKTOP PALAEONTOLOGICAL IMPACT ASSESSMENT

LANGA SOLAR ENERGY FACILITY, BERLIN, AMATHOLE DISTRICT, EASTERN CAPE, RSA

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DATE: 28 April 2011

SUMMARY

Langa Energy (Pty) Ltd. are applying for authorisation to develop a solar energy facility at Berlin, on the N2 between King William's Town and East London, in the Amatole District (Buffalo City Local Municipality), Eastern Cape. Situated on 150 Ha of land currently zoned for agriculture, adjacent to the Berlin industrial complex, the proposed facility would comprise around 208 photovoltaic arrays with an estimated power output of 100MW.

The area to be developed is underlain by Late Permian-aged rocks of the Beaufort Group, Adelaide Subgroup, more specifically the lowermost Balfour Formation, in the *Cistecephalus* Assemblage Zone. Rocks of the Beaufort Group, especially further west of the development site, are internationally recognised for their diverse and highly significant vertebrate fossil record. These rocks are also host to trace fossils (including tetrapod trackways) and plants (*Glossopteris* floras).

Rocks within the *Cistecephalus* AZ in the development footprint of the Langa Solar Energy Facility are therefore considered to be of high palaeontological significance/sensitivity, although fossil densities may be low and of sporadic occurrence.

Excavations for the construction of access roads, building foundations and concrete feet for the arrays, may intersect potentially fossiliferous bedrock. Although the chances of finding fossils in these limited exposures is slim, **these excavations must be carefully monitored by the ECO. Any fossil occurrences must be reported to SAHRA and/or a qualified palaeontologist for further assessment and excavation.** Damage to or destruction of any fossil during construction would be a **highly negative, permanent impact**. Discovery of fossils during excavation, followed by effective mitigation in collaboration with a palaeontologist, would result in the curation of new and important fossil material – therefore the development **could potentially have a positive**, **beneficial impact** on South Africa's palaeontological heritage.

Impact significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale**	**Spatial Scale**	**Degree of confidence**	**Impact severity**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Balfour Formation	permanent	international	unsure	beneficial	very severe	beneficial	high negative

NOTE: fossil occurrences are important but rare in this area

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INTRODUCTION

Langa Energy (Pty) Ltd. plan to develop a 100 MW solar power generation facility at Berlin, on the N2 between King William's Town and East London, in the Amatole District (Buffalo City Local Municipality), Eastern Cape. Situated on 150 Ha of land currently zoned for agriculture, adjacent to the Berlin industrial complex, the proposed facility would comprise around 208 photovoltaic arrays.

As part of an application to the Department of Environmental Affairs (DEA) for permission to undertake this development, Coastal & Environmental Services (CES) were appointed by Langa Energy (Pty) Ltd in the capacity of Environmental Assessment Practitioner (EAP) to conduct an Environmental Impact Assessment (EIA). Umlando cc. was contracted by CES to perform the heritage impact component of the assessment, and the current study represents the palaeontological component (palaeontological impact assessment - PIA) of the heritage impact assessment (HIA). The purpose of this desktop PIA is to identify potential palaeontological heritage on the site of the proposed development, to assess the impact the development may have on this resource, and to make recommendations as to how this impact might be mitigated.

Relevant Legislation

Protection of South Africa's environmental resources is regulated by the Department of Environmental Affairs (DEA), in part through the National Environmental Management Act ("NEMA" Act 107 of 1998). In accordance with the Act, developers must apply to the competent authority for approval of their plans, which is subject to assessment of the anticipated impacts these activities will have on the environment. Activities are categorised according to the 2010 *Government Listing Notices 1 (GN R544), 2 (GN R545) & 3 (GN R546)* issued by the DEA. In cases where impact is considered to be minimal (*Listing Notices 1 & 3*), the applicant is required to submit a basic assessment report with their application. When a greater degree of disturbance is expected *(Listing Notice 2)*, then a more rigorous, two-tiered assessment may be required, comprising a Scoping Report, followed by a full Environmental Impact Assessment (EIA).

Because the proposed development triggers two listed activities from GN R545, the Langa solar energy project is subject to the requirement for both a Scoping Assessment and full EIA (see table below).

The Langa solar energy project is subject to assessment in terms of the following listed activities (extracted from the scoping report issued by CES, 2010):

Activity No (s)		Required assessment	Listed activity
GN R544	**10 (i)**	Basic Assessment	The construction of facilities or infrastructure for the transmission and distribution of electricity outside urban areas or industrial complexes with a capacity of more than 33 but less than 275 kilovolts.
GN R545	**1**	EIA	The construction of facilities or infrastructure for the generation of electricity where the electricity output is 20 megawatts or more.
GN R545	**15**	EIA	Physical alteration of undeveloped, vacant or derelict land for residential, retail, commercial, recreational, industrial or institutional use where the total are to be transformed is 20 hectares or more
GN R546	**14 (a) i**	Basic assessment	The clearance of an area of 5 hectare or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation in all areas outside urban areas (in the Eastern Cape).

The primary piece of legislation protecting *national heritage* in South Africa, is the **South African Heritage Resources Act (Act No. 25) of 1999**. In accordance with Section 38 (Heritage Resources Management) of the act, developers must apply to the relevant authority (South African Heritage Resources Agency - SAHRA) for authorisation to proceed with their planned activities. This application must be accompanied by documentation detailing the expected impact this will have on national heritage in particular.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

To address concerns relating to the protection of these particular heritage resources, a Heritage Impact Assessment (HIA) is a required component of the EIA, to assess any potential impacts to archaeological and palaeontological heritage within the development footprint. This report represents the palaeontological component of the HIA.

PROPOSED DEVELOPMENT

According to the Scoping Report issued by CES (2010), Langa Energy (Pty) Ltd. plan to develop a pilot-scale photovoltaic array for solar energy generation that will produce an estimated 100MW of electricity.

Photovoltaic arrays:

Around 208 photovoltaic arrays are planned. Individual arrays are 1.9m^2 (0.99m x 1.96m) in size, and are mounted on a metal frame, supported by a pole that is anchored by means of a small concrete foot. The arrays will cover an area of 6.9 ha, although the actual area impacted directly by construction will be a lot less - only the localised sites where the concrete footpieces are embedded may have an impact on the underlying bedrock.

Additional, supporting infrastructure would include:

- roads - single track gravel access roads with a length of 12 km;
- electrical infrastructure - 100 group stations with a total footprint of 1000m^2; underground electricity cables; single main station (10m^2 footprint);
- maintenance facility - 1000 m^2 garage and storage;
- fencing for security reasons, along perimeter of facility;
- small control cabin at the entrance to the facility.

Location of proposed development

The development footprint will span 150 ha over four properties currently zoned as Agriculture 01 (Farm/Erf. Nos 1875/1, 1877/3, 1 and 8) alongside the N2, adjacent to the industrial complex in Berlin, Buffalo City Local Municipality, between East London and King William's Town, in the Amatole District (Figs 1, 2 & 3).

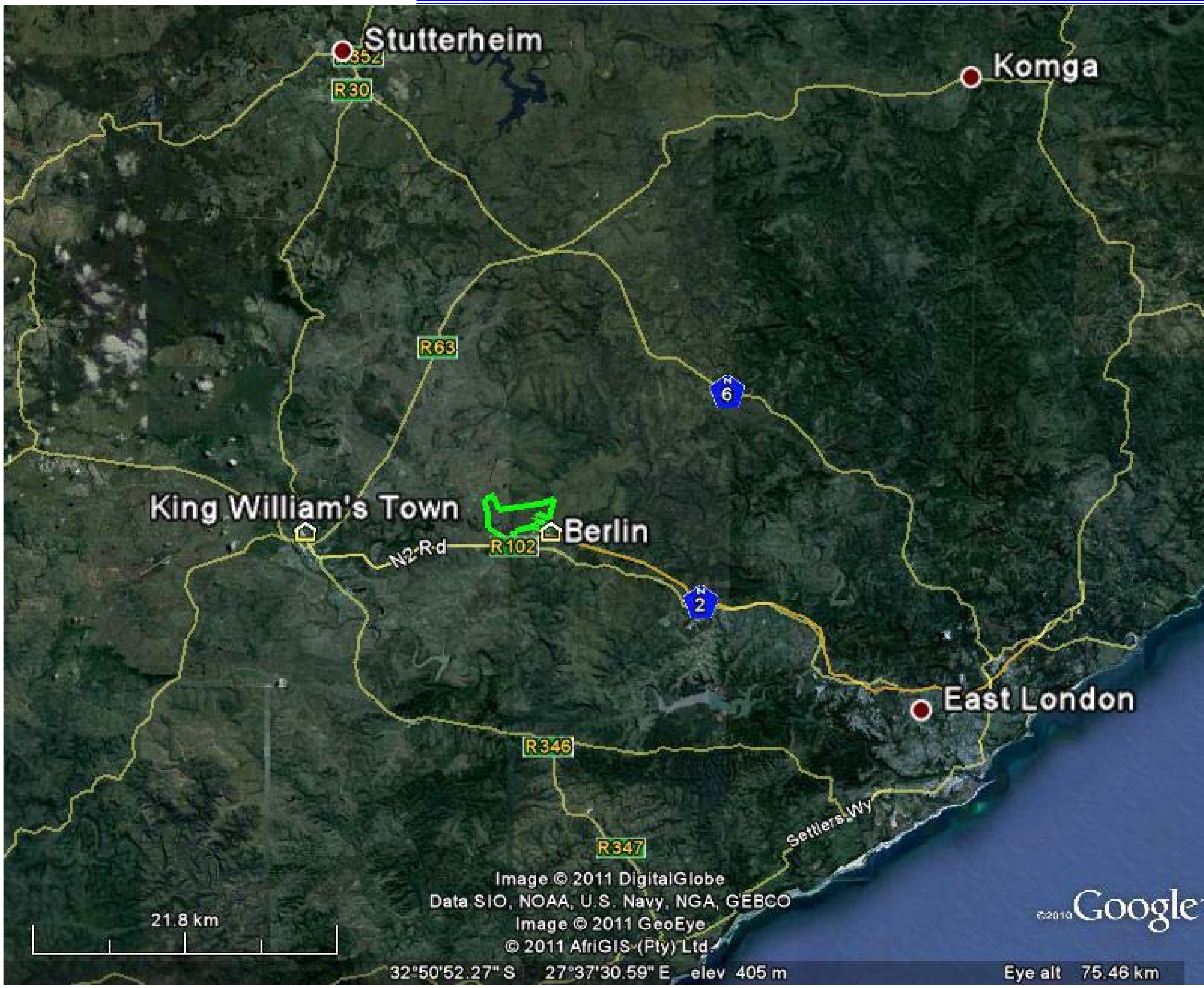

FIG. 1. General location and extent of the proposed Langa Solar Energy Project (green outline).

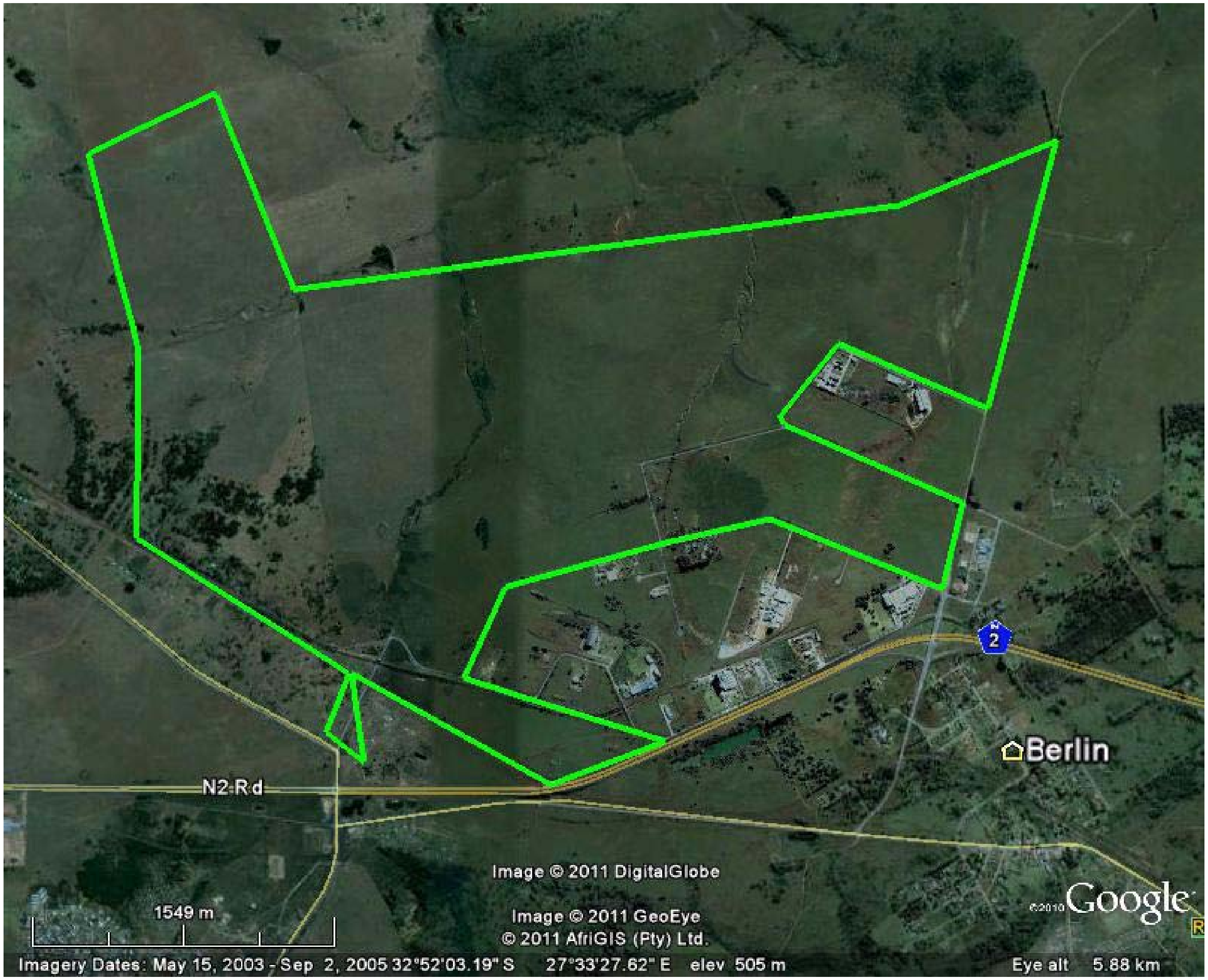

FIG. 2. Langa Solar Energy Facility – Google map of proposed location of photovoltaic facility (green outline).

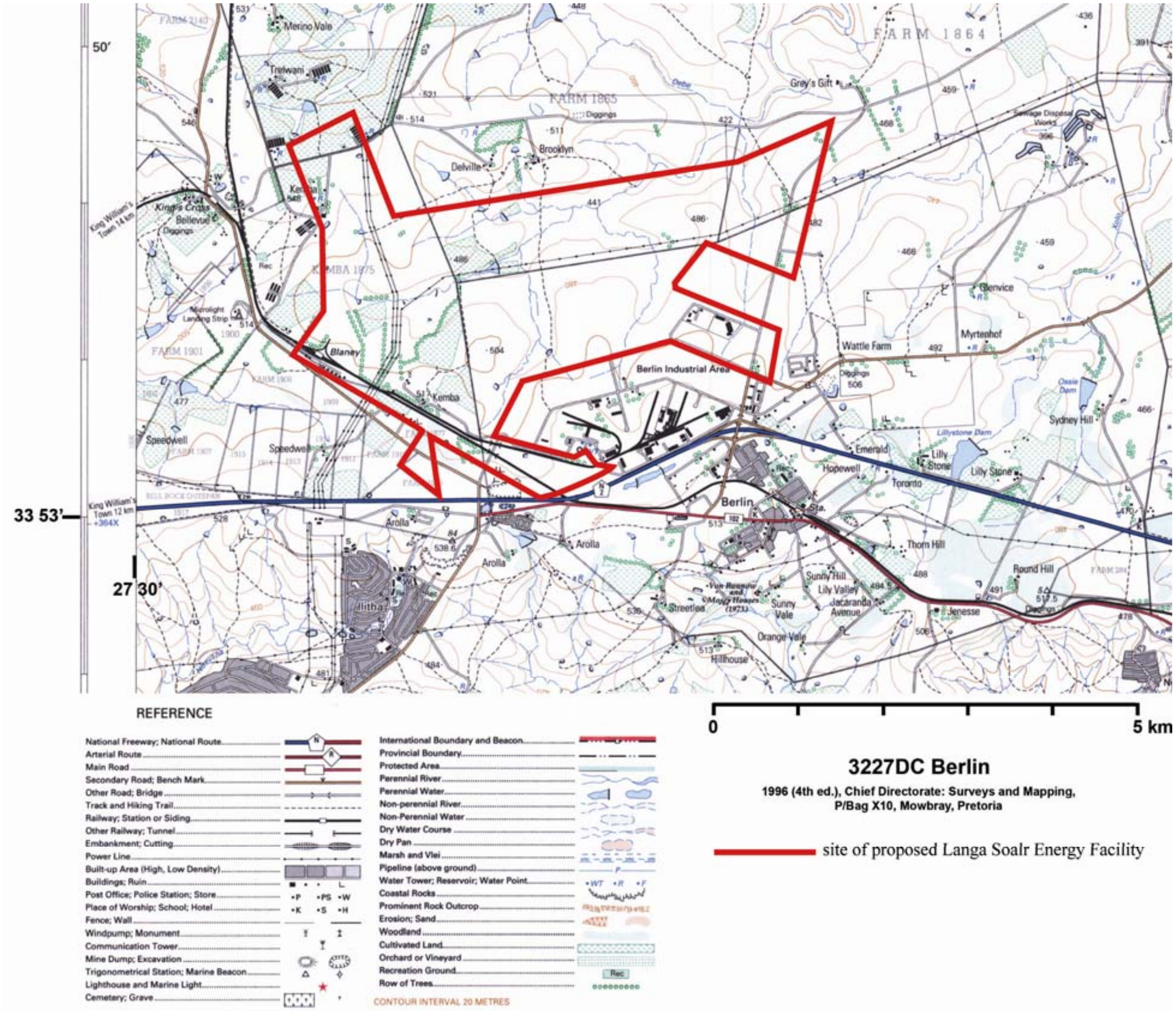

FIG. 3. Extract from the 1:50 000 topographic map 3227 DC Berlin, illustrating the proposed site of the Langa solar energy facility at Berlin, Eastern Cape.

FIG. 4. Two views of the area earmarked for the Langa solar power facility, illustrating the flat topography, dense grass cover and as a result, an almost complete lack of rock exposure (photographs provided by Gavin Anderson, Umlando).

AIMS AND METHODS

This report represents the palaeontological component of a Heritage Impact Assessment (HIA), as per the latest version of the SAHRA guidelines (May 2007, revised 2009). The aims of the desktop PIA are to assess the potential palaeontological heritage of the area targeted for development by:

1) identifying exposed and subsurface rock formations that are considered to be palaeontologically significant;
2) assessing the level of palaeontological significance of these formations;
3) commenting on the impact of the development on these potential fossil resources;
4) making recommendations as to how the developer should conserve or mitigate damage to these resources.

A field examination of the area was not undertaken since rock outcrop within the development footprint was apparently absent or near-absent, as evident from Google Earth images (Fig. 2), topographic maps (Fig. 3) and photographs (Fig. 4) of the site. Presumably, the lack of topography is one of the reasons the site was selected for the construction of PV arrays. The only places there may be some minor outcrop exposed, are along the gullies that traverse the property, although these do not appear to be deep, and probably do not intercept bedrock. Plans for the development indicate that the gullies/streams will be avoided (CES, 2010; fig. 2-3).

For the desktop study, a basic assessment of the topography and geology of the area was made using appropriate geological (1:250 000) maps in conjunction with Google Earth. A review of the literature (including PIA reports available on the internet) was undertaken, on the geological formations exposed at surface within the development site, and the fossils that have been associated with these geological strata in the former Transkei and elsewhere in South Africa.

GEOLOGICAL AND PALAEONTOLOGICAL CONTEXT

Regional and local geology

According to the 1:250 000 geological map of the King William's Town region (3226; 1976), the underlying rocks in the area fall within the palaeontologically highly significant **Beaufort Group** (Fig. 5), of the Karoo Supergroup, in the south-eastern reaches of the main Karoo Basin.

The entire area was heavily intruded by **dolerite dykes and sills** during Jurassic times (scattered pink areas in Fig. 6; [Jd]). Because of the igneous nature of these rocks, they have no palaeontological potential, and are not considered further here.

The Beaufort Group, underlain conformably by the predominantly deep-water mudrocks of the Ecca Group, is characterized as a fluvial succession comprising upward-fining sequences of mudrock and sandstones, the latter mostly representing channel fills (Fig. 5; see Hancox & Rubidge, 2001 for overview). The Beaufort Group is divided into two subgroups, viz. the Upper Permian, Adelaide Subgroup (pale blue-green, [Pub] in Fig. 6) and the overlying Lower to Mid-Triassic, Tarkastad Subgroup (yellow-green, [Trlk] in Fig. 6).

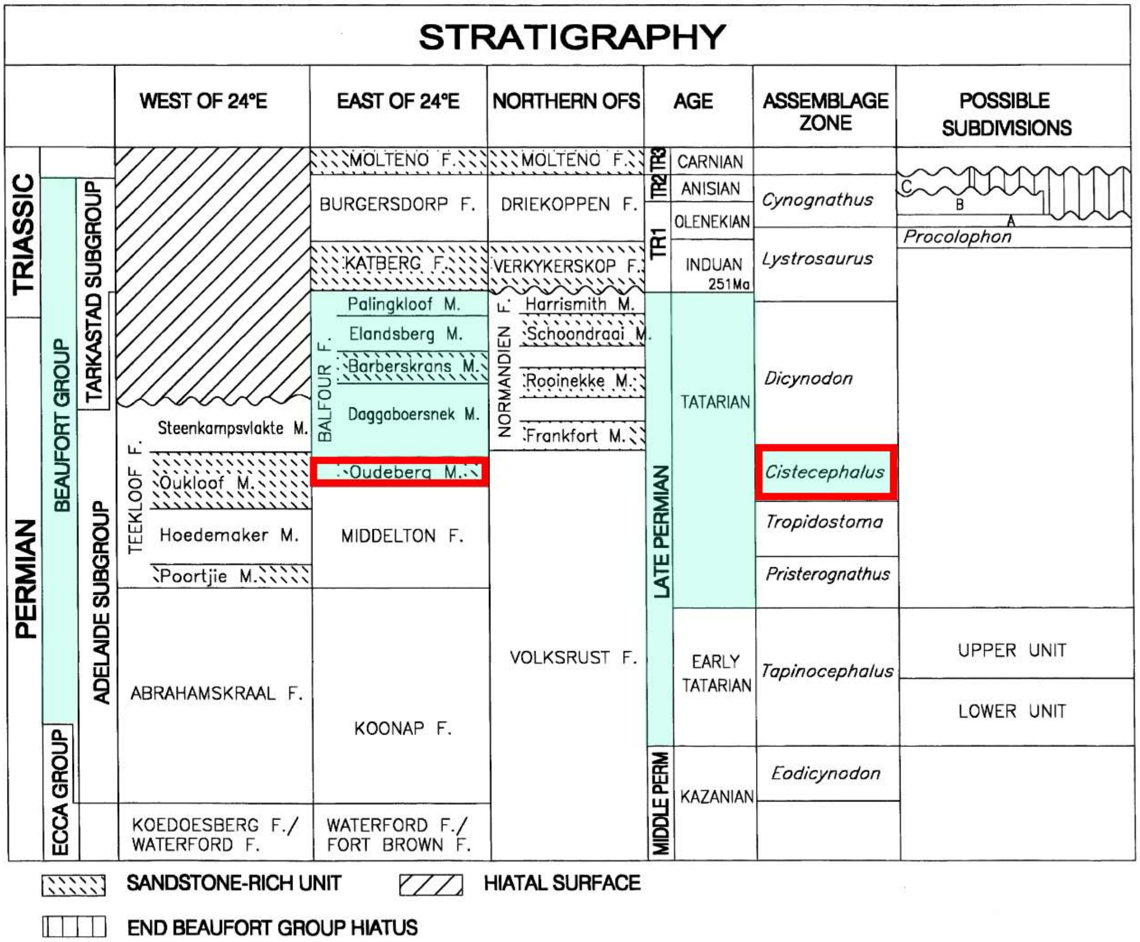

FIG. 5. Lithostratigraphic and biostratigraphic subdivisions of the Beaufort Group, Karoo Supergroup, Main Karoo Basin, with lowermost Balfour Formation indicated in red (adapted from Hancox & Rubidge 2001).

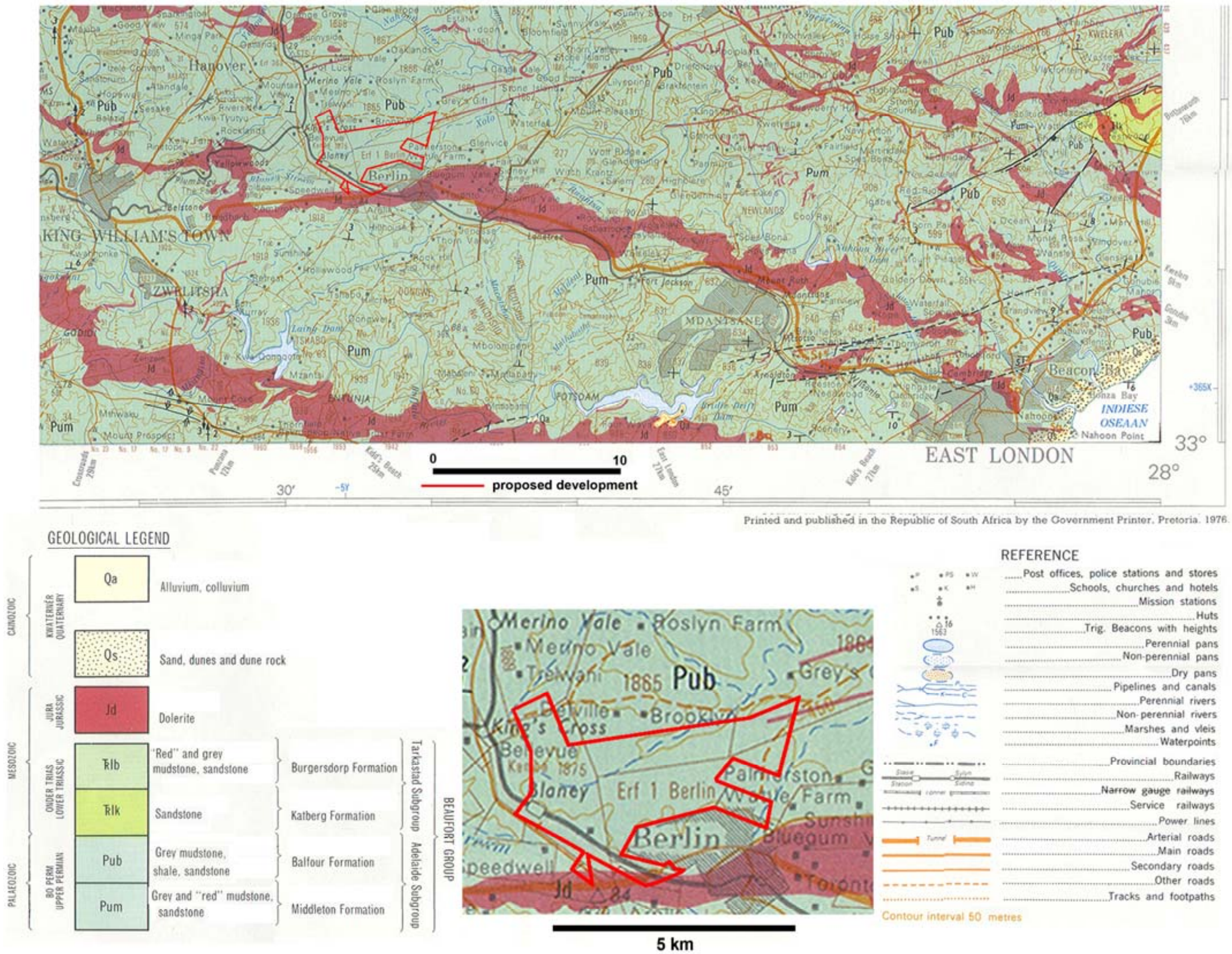

FIG. 6. Regional and local geology, as mapped in the vicinity of the proposed Langa Solar Energy Facility (site outlined in red).

(Extract from the 1:250 000 geological map, 3226 King William's Town; compiled by M.R. Johnson, 1976; Council for Geoscience, Pretoria).

The area targeted for development by Langa Energy is underlain by rocks of the **Adelaide Subgroup** (Fig. 6, outline). In this region the Adelaide subgroup comprises rocks of the **Middleton** and **Balfour formations**. The boundaries of these formations are not well defined in the Berlin area, and are not marked in on the 1:250 000 Geological map of the area (Fig. 6). This is because the limits of the formations are not well constrained in the absence of good exposure in the area, as well as the abundance of faults that disrupt the lateral continuity of the formations as they outcrop on the surface (Johnson & Keyser, 1976).

As described by Johnson & Keyser (1976) and Karpeta & Johnson (1979) both rock formations comprise repeating layers, a few to tens of meters thick of grey fine-grained sandstone (approx. 25%) and greenish-grey, bluish-grey and (in the Middleton Formation only) grayish-red mudstone (approx. 75%). Upward-fining sequences are common in both formations, the major difference between them being the presence of grayish-red mudrock throughout the Middleton Formation, whereas the Balfour Formation only has reddish mudstones in the very uppermost ~100m (the Palingkloof Member).

The 1:250 000 geological map in Fig. 6 suggests that the rocks underlying the site of the Langa solar energy facility fall within the lowermost Balfour Formation.

Palaeontological Heritage

The great palaeontological value of the Beaufort Group is internationally recognised, as it represents the most continuous terrestrial fossil record of life during a critical time in evolutionary history. These rocks document plant and animal life over a time-span ranging from the Middle Permian to the Middle Triassic, recording important evolutionary events such as the transition from reptiles to mammals (e.g. Hancox & Rubidge, 2001; McCarthy and Rubidge, 2005), and reflecting the major biotic turmoil associated with the most dramatic extinction event in Earth's history – the Permian/Triassic extinction. This latter event occurred some 251 million years ago, and is marked in the fossil record by a massive turnover of plant and animal species (eg. Erwin 1994; Smith & Ward, 2001; McCarthy & Rubidge, 2005; Smith & Botha, 2005).

In addition to the evolutionary insights provided by the Beaufort Group fossils, the profuse and continuous fossil record available to palaeontologists has enabled them to develop an effective biostratigraphic framework for a succession that has few geological features allowing for its subdivision (e.g. SACS, 1980). In South Africa there has been a long tradition of vertebrate faunal studies and their biostratigraphic utilization in the Beaufort Group (Broom, 1906; Keyser & Smith 1977-78; Rubidge, 1995; Hancox & Rubidge, 2001; Cataneaunu *et al.*, 2005; Rubidge, 2005), and the Assemblage Zones (AZ) that have been recognised as a result of this work can be followed across much of South Africa (Fig. 5).

Most of the work relating to biozonation of the Eastern Cape Beaufort Group deposits, stems from studies of the geology and fossils further west, towards Graaff Reinet, where exposures (and therefore fossil discoveries) are more abundant. The proposed site for the Langa solar energy facility overlies rocks that most likely fall within the *Cistecephalus* Assemblage Zone (Rubidge, 2005).

***Cistecephalus* AZ fossils**

Vertebrate fossils

As detailed by Smith & Keyser (1995) the *Cistecephalus* AZ occupies the lowermost part of the Balfour Formation and the uppermost part of the Middleton Formation. It is characterised by the presence of therapsid genera *Cistecephalus*, *Aulacephalodon* and *Oudenodon*. The remains of these creatures are generally found in interchannel mudrocks, as dispersed, isolated fossils, or rarely denser accumulations may be encountered. Fossil bone material can vary in colour from black to grey-blue to pure white, depending on the area and whether the host strata have been affected by metamorphic processes.

A diversity of vertebrates has been documented from the *Cistecephalus* AZ in South Africa (taken from Smith & Keyser, 1995):

Amphibians: *Rhinesuchus*;

Fish: *Atherstonia, Namaichthys digitata*;

Reptiles: captorhinids *Owenetta* and *Pareiasaurus*;

Therapsids (so-called 'mammal-like reptiles'): therocephalians *Ictidosuchops*, *Ictidosuchoides,* gorgonopsians *Gorgonops, Lycaenops, Cyonosaurus, Arctognathus, Clelandina, Cyonosaurus, Dinogorgon, Prorubidgea, Rubidgei*, biarmosuchian *Lemurosaurus*, dicynodonts *Aulacephalodon*, *Cistecephalus, Diictodon, Dinanomodon, Emydops, Endothiodon, Oudenodon, Platycyclops*, *Pristerodon* and *Rhachiocephalus*.

Invertebrate fossils

Insects: The only insects that have been found in the Balfour Formation, are those that were discovered at the Wapadsberg Pass locality near Nieu Bethesda in the Eastern Cape (Prevec *et al.*, 2010; unpubl. data). Rocks at this locality are slightly younger than those at Berlin, belonging to the *Dicynodon* AZ (uppermost Balfour Formation, Palingkloof Member).

Molluscs: *Palaeomutela* (Smith & Keyser, 1995)

Trace Fossils

Invertebrate trace fossils, tetrapod trackways, e.g. a trackway described from the *Cistecephalus* AZ near Graaff Reinet in the Eastern Cape, thought to have been produced by the therapsid *Aulacephalodon* (de Klerk, 2002).

Plant fossils

Important fossil floras are known from stratigraphic equivalents of the Balfour Formation in the north-eastern parts of the Karoo basin - the Normandien Formation (previously Estcourt Formation) and Emakwezini Formation. These floras, dominated by *Glossopteris*, with subsidiary elements comprising sphenopsids (particularly *Phyllotheca australis*), ferns, conifers, and very rare lycopsids and mosses, are currently recognised as Late Permian floras, and mostly fall within the *Dicynodon* AZ (Anderson & Anderson, 1985; Gastaldo *et al.*, 2005; Bordy & Prevec, 2008; Prevec *et al.*, 2009, 2010).

With the exception of a single latest Permian locality, in the uppermost Balfour Formation near Nieu Bethesda in the Eastern Cape (Prevec et al. 2010), comprehensive documentation of floras from the southern and south-eastern parts of the Karoo Basin is absent, although silicified wood has been found throughout the Adelaide Subgroup (Johnson & Keyser, 1976; Bamford, 1999, 2004). The apparent scarcity of floras in the southern and western main Karoo Basin can be attributed partly to taphonomic (preservational) reasons (Gastaldo et al., 2005), and partly to a lack of concerted effort historically to look for and document plants in these regions. Although there are currently no useful floral analogues in the literature that could be utilized in predicting what fossil plants may be found in the Berlin area, recent reconnaissance efforts to find plant fossils in the Eastern Cape yielded several new sites (Linkermann *et. al.* 2010). These produced *Glossopterid*-dominated floras with subsidiary sphenopsid elements.

It should be noted that fossil occurrences of both plants and animals in the Beaufort Group, particularly in the lowermost successions, are generally considered to be rare (e.g. Anderson & Anderson, 1985; de Klerk, 2011).

PREDICTED IMPACT OF PROPOSED DEVELOPMENT

The proposed development, involving the installation of photovoltaic arrays and associated infrastructure including roads and buildings, has the potential to impact on fossil heritage, as construction will inevitably require excavation of bedrock (Tables 1, 2).

If excavations of fresh bedrock are monitored adequately during the course of the proposed development, then any fossil discovery made in the process could be seen as facilitating a significant scientific advancement. However, if mitigation measures, such as vigilant inspection of excavations into bedrock by an ECO, are not carried out, and fossil material is destroyed during the construction phase of the development, then this could be seen as a permanent, severely negative impact on South Africa's fossil heritage.

However, it should be noted that only small quantities of bedrock would probably be exposed (at fairly shallow depth) during the construction of the photovoltaic arrays. This decreases the likelihood of the developers encountering (rare) fossils during their excavations.

RECOMMENDATIONS/ MITIGATION

Although the installation of photovoltaic arrays at Berlin is unlikely to lead to exposure of much in the way of fresh bedrock, the soils in the region are shallow (CES, 2010), and it is not inconceivable that fossiliferous material may be exposed during excavations for the concrete 'feet' of the arrays. This is particularly true for any excavations during construction of access roads. If bedrock is intersected, the responsible Environmental Control Officer (ECO) must inspect the excavations at regular intervals, for the presence of fossil material.

If fossil material is exposed by the developers, it must be reported immediately to the on-site Environmental Control Officer (ECO), and to SAHRA, so that an appropriate palaeontological expert can be consulted to further assess, record and professionally excavate or sample the material. If feasible, the exposed fossil material should be photographed (with a scale), covered over with loose sediment (or otherwise protected from the elements), and the site carefully recorded (GPS reading/ 1:50 000 map/aerial photograph).

It should also be noted that it is not just the actual bone/plant material/shell etc. itself that is of interest and importance to a palaeontologist. Increasingly, scientists appreciate the value of information evident in the immediate vicinity of fossils that is not necessarily inherent to the fossil itself, such as the geology of the host rock stratum, the orientation of individual fossil organs, organism associations, preservational aspects etc. These types of information can provide important clues about past environments, and can help to place fossils within their original context. This information can be lost through indiscriminate sampling by untrained personnel.

CONCLUSIONS

In principle, and on purely palaeontological grounds, there are no objections to the proposed development. Because of the high palaeontological sensitivity of the underlying Beaufort Group rocks, the Langa solar power development has been assigned a palaeontological impact rating of high, however, the minimally invasive nature of the development, the lack of outcrop in the development footprint, and the rarity of fossils in the lower Beaufort Group, (Tables 1 and 2) attenuate this rating in practical terms. Certain mitigation measures are nonetheless required: any excavations into bedrock must be monitored for the presence of fossils by the ECO. If any fossils are exposed during construction, the material must be appropriately protected, and the discovery reported to a local palaeontologist (Albany Museum) for assessment and removal.

Table 1: Regional palaeontological significance of geological units present on site

GEOLOGICAL UNIT				ROCK TYPE AND AGE	FOSSIL HERITAGE	VERTEBRATE BIOZONE	PALAEON-TOLOGICAL SENSITIVIY	RECOMMENDED MITIGATION
KAROO SUPERGROUP	DRAKENSBERG GROUP			dolerite dykes and sills (igneous intrusives)	none	none	**NIL**	none
KAROO SUPERGROUP	BEAUFORT GROUP	Adelaide Subgroup	**Balfour Formation**	predominantly argillaceous LATE PERMIAN (Tatarian)	vertebrate fossils including a variety of therapsids, amphibians, true reptiles, fish, trace fossils and freshwater molluscs; trace fossils, including tetrapod trackways; plant fossils predominantly *Glossopteris* and sphenopsids (horse-tail ferns); fossil wood	*Lystrosaurus* AZ *Dicynodon* AZ *Cistecephalus* AZ	**High sensitivity**	regular monitoring of any excavations into bedrock; in the event of fossils being encountered, excavation should cease until a palaeontologist can assess, extract and document the find
KAROO SUPERGROUP	BEAUFORT GROUP	Adelaide Subgroup	Waterford Formation	LATE PERMIAN (Tatarian)		*Cistecephalus* AZ *Tropidostoma* AZ *Pristerognathus* AZ		

Table 2: Significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale** (duration of impact)	**Spatial Scale** (area in which impact will have an effect)	**Degree of confidence** (confidence with which one has predicted the significance of an impact)	**Impact severity** (severity of negative impacts, or how beneficial positive impacts would be)		**Overall Significance** (The combination of all the other criteria as an overall significance)	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Balfour Formation	permanent	international	unsure (fossils rare, limited exposure of potentially fossiliferous rocks)	beneficial	very severe	beneficial	high negative

Explanation: There is a **possibility** that fossils could be encountered during excavation of bedrock within the development footprint. These fossils would be of **international significance**. If effective mitigation measures were in place at the time of exposure, and they were successfully excavated for study, this would represent a **beneficial** impact. Alternatively, if fossil specimens were destroyed in the absence of adequate monitoring during construction activities, this would represent a **permanent, very severe, highly negative** impact on South Africa's palaeontological heritage.

The possibility of encountering fossils in the region is low in any small, localized site, as fossils in the lowermost Beaufort Group are fairly rare. There is no way of assessing or quantifying the likelihood of encountering fossils during excavation, especially as a regional field survey is not feasible because of a lack of outcrop in this flat, grassy region.

Fossils within the development footprint could be characterized as **rare, but highly significant**, and any damage to, or loss of, these fossils due to inadequate mitigation would be a **highly negative palaeontological impact.** However, exposure and subsequent reporting of fossils (that would otherwise have remained undiscovered) to a qualified palaeontologist for excavation, could be seen as a **beneficial palaeontological impact**.

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QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr Rose Prevec has PhDs in Palaeontology and Plant Pathology from the University of the Witwatersrand (2005) and University of KwaZulu-Natal (1998) respectively. She specialises in research on South African Permian macrofossil floras, with an interest in taxonomy, biostratigraphy, and palaeoecological aspects such insect-plant interactions. She has held three postdoctoral fellowships, at Wits and Rhodes University, and is currently a Research Associate at the Albany Museum in Grahamstown. Dr Prevec has more than 10 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, eastern and north-eastern parts of the country. Her publication record includes multiple articles in internationally recognized journals. Dr Prevec is accredited by the Palaeontological Society of Southern Africa (society member for 13 years, and a member of the Executive Committee for 4 years).

Declaration of Independence

I, Rosemary Prevec, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr Rosemary Prevec
Palaeontologist

PIA APPENDIX I: EXPLANATION OF RISK AND SIGNIFICANCE RATINGS
(Compiled by CES)

Table A1: Criteria used to rate the significance of an impact

Significance Rating Table	
Temporal Scale (The duration of the impact)	
Short term	Less than 5 years (Many construction phase impacts are of a short duration).
Medium term	Between 5 and 20 years.
Long term	Between 20 and 40 years (From a human perspective almost permanent).
Permanent	Over 40 years or resulting in a permanent and lasting change that will always be there.
Spatial Scale (The area in which any impact will have an affect)	
Individual	Impacts affect an individual.
Localised	Impacts affect a small area of a few hectares in extent. Often only a portion of the project area.
Project Level	Impacts affect the entire project area.
Surrounding Areas	Impacts that affect the area surrounding the development
Municipal	Impacts affect either the Local Municipality, or any towns within them.
Regional	Impacts affect the wider district municipality or the province as a whole.
National	Impacts affect the entire country.
International/Global	Impacts affect other countries or have a global influence.
Degree of Confidence or Certainty (The confidence with which one has predicted the significance of an impact)	
Definite	More than 90% sure of a particular fact. Should have substantial supportive data.
Probable	Over 70% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Only over 40% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact, or of the likelihood of an impact occurring.

Table A2: The severity rating scale

Impact severity (The severity of negative impacts, or how beneficial positive impacts would be on a particular affected system or affected party)	
Very severe	**Very beneficial**
An irreversible and permanent change to the affected system(s) or parties which cannot be mitigated. For example the permanent loss of land.	A permanent and very substantial benefit to the affected system(s) or parties, with no real alternative to achieving this benefit. For example the vast improvement of sewage effluent quality.
Severe	**Beneficial**
Long term impacts on the affected system(s) or parties that could be mitigated. However, this mitigation would be difficult, expensive or time consuming, or some combination of these. For example, the clearing of forest vegetation.	A long term impact and substantial benefit to the affected system(s) or parties. Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example an increase in the local economy.
Moderately severe	**Moderately beneficial**
Medium to long term impacts on the affected system(s) or parties, which could be mitigated. For example constructing the sewage treatment facility where there was vegetation with a low conservation value.	A medium to long term impact of real benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example a 'slight' improvement in sewage effluent quality.
Slight	**Slightly beneficial**
Medium or short term impacts on the affected system(s) or parties. Mitigation is very easy, cheap, less time consuming or not necessary. For example a temporary fluctuation in the water table due to water abstraction.	A short to medium term impact and negligible benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.
No effect	**Don't know/Can't know**
The system(s) or parties are not affected by the proposed development.	In certain cases it may not be possible to determine the severity of an impact.

Table A3: The rating of overall significance

Overall Significance (The combination of all the above criteria as an overall significance)	
VERY HIGH NEGATIVE	**VERY BENEFICIAL**
These impacts would be considered by society as constituting a major and usually permanent change to the (natural and/or social) environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects. **Example:** The loss of a species would be viewed by informed society as being of VERY HIGH significance. **Example:** The establishment of a large amount of infrastructure in a rural area, which previously had very few services, would be regarded by the affected parties as resulting in benefits with VERY HIGH significance.	
HIGH NEGATIVE	**BENEFICIAL**
These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by society as constituting an important and usually long term change to the (natural and/or social) environment. Society would probably view these impacts in a serious light. **Example:** The loss of a diverse vegetation type, which is fairly common elsewhere, would have a significance rating of HIGH over the long term, as the area could be rehabilitated. **Example:** The change to soil conditions will impact the natural system, and the impact on affected parties (such as people growing crops in the soil) would be HIGH.	
MODERATE NEGATIVE	**SOME BENEFITS**
These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by society as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial. **Example:** The loss of a sparse, open vegetation type of low diversity may be regarded as MODERATELY significant.	
LOW NEGATIVE	**FEW BENEFITS**
These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect. **Example:** The temporary change in the water table of a wetland habitat, as these systems is adapted to fluctuating water levels. **Example:** The increased earning potential of people employed as a result of a development would only result in benefits of LOW significance to people who live some distance away.	
NO SIGNIFICANCE	
There are no primary or secondary effects at all that are important to scientists or the public. **Example:** A change to the geology of a particular formation may be regarded as severe from a geological perspective, but is of NO significance in the overall context.	
DON'T KNOW	
In certain cases it may not be possible to determine the significance of an impact. For example, the primary or secondary impacts on the social or natural environment given the available information. **Example:** The effect of a particular development on people's psychological perspective of the environment.	